1. Introduction to *Water Markets*: an overview and systematic literature review

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1.1 PREFACE

This book, *Water Markets: A Global Assessment*, includes chapters written by water policy expert scholars highlighting the extent of water markets in 20 countries (and across 28 country areas/basins) around the world. Our case studies include countries within Africa, Asia, Europe, North America, Oceania and South America. The aims of this book are: (1) to provide information on the adoption of water markets around the world; (2) to clarify the range of contexts and issues in which water markets successfully emerge (through the application of a water market readiness framework); and (3) to provide practical insights and guidance on water markets for water managers, academics and research students, industry organisations and government policy-makers. This chapter provides an introduction and a systematic review of the water market literature to date.

1.2 BACKGROUND

There are grave concerns regarding future trends in water scarcity across the world, and the challenge of reconciling water supply and demand will intensify as water extractions increase (Barbier, 2019; Grafton et al., 2018). Water issues are often described as a ‘wicked problem’ because they have multiple, interconnected causes; whilst having many possible solution perspectives (Grafton and Wheeler, 2015; Quiggin, 2001). Hanemann (2006) describes nine economic aspects of water that presents issues for its management: (1) water has both private and public good aspects; (2) water’s mobility; (3) water’s variability; (4) cost of water; (5) price of water; (6) essentialness of water; (7) heterogeneity of water; (8) fallacy/misconception of using average value; and (9) benefits of water.

Policy-makers have a range of options to improve water management and allocation, and these very broadly fall into water supply augmentation and water demand management. Supply augmentation – otherwise known as ‘hard’ infrastructure or engineering solutions to increase water supply (for example, dam, irrigation infrastructure and weir construction) or substitution (for example, desalinated water) – has traditionally been the most promoted because it offers a technical and relatively rapid (and occasionally efficient where there are low marginal costs) method to address water scarcity (Wheeler and Garrick, 2020). Water demand-side management – otherwise known as ‘soft’ infrastructure and governance – includes educational measures (for example, information and campaigns), regulatory and/or planning processes (for example, legislation and regulation) and economic incentives (for example, economic pricing, subsidies and/or property right changes that allow water markets) (Wheeler and Garrick, 2020). Ideally both demand and supply responses should be integrated to address water security; however, this is frequently not the case (Barbier, 2019; Griffin, 2006; Sadoff et al., 2015).

Given that the choice of cost-effective supply augmentation projects is diminishing around the world, increasingly water demand management, and in particular water markets, will be further considered and implemented to address water scarcity and quality issues. However, little is known about the applicability of water markets, and what advice practitioners can use to assess how suitable their water resource situation is for water markets.

Water markets are often identified as an important way forward for addressing scarce water supply and increasing demand (Gómez Gómez et al., 2018). Previous books on water markets include (but are not limited to) Easter et al. (1998), Easter and Huang (2014) and Maestu (2013). Economists in particular believe in the power of markets to effectively and efficiently reallocate resources at the margin of use, and many argue that water trading is currently underutilised as a management option. On the other hand, there are many critics of water markets, arguing that ‘water is too different to sell’ (Griffin et al., 2013, p. 2). Griffin et al. (2013, p. 3) summarise this view of water trading opponents as espousing a water-is-different view that exaggerates biological requirements for water, confuses capital scarcity with water scarcity, seeks to preserve agrarian economies and claims public entitlement to water. On the other hand, Griffin et al. (2013) state that some economists over-emphasise the ‘water is no different from other commodities’ argument, and have too much faith in the market system resulting in an efficient economy.

We agree with Griffin et al. (2013) that water is sufficiently different to other commodities to mean that water markets are not automatically a panacea, and that certain water market failures may mean a net cost for society. There is a need for a variety of conditions to be met for water markets to be successful.

Indeed, water markets are not an easily adopted or implemented solution, often requiring significant time periods and political/financial investment.

1.3 WHAT IS WATER TRADING?

Water trading occurs in water markets, and can be defined as the process of buying and selling water licences (also called entitlements or rights). Three broad types of water trading can be defined: (1) short-term or temporary transfers of water (also known as water allocation trade); (2) medium-term leasing of water allocations to secure access to water for a period of time specified in a contract (also known as water leasing); and (3) permanent transfers of water entitlements – namely: (a) the ongoing property right to either a proportion or fixed quantity of the available water at a given source (also known as water entitlement trading); and (b) water delivery rights, that is, the right to have water delivered (Wheeler and Garrick, 2020).

In short, formal water markets involve reforming water law to transform water public property rights to a situation where some water use rights are divisible, transferable, privately managed and can be bought or sold (in whole or part) (Griffin et al., 2013). Formal water trading arrangements may comprise sanctioned rules, processes, catchment areas managed by governments and/or communities. Hence, water trading can change the location, timing and technical efficiency of water use (Easter et al., 1999; Howe et al., 1986). Formal water markets have evolved widely in the world since the 1970s (Chong and Sunding, 2006), and exist in differing stages across many countries in the world, as illustrated in this global water markets book. Formal water markets can be slow to develop in some regions for a number of reasons, such as local political circumstances and the interrelated nature of water use (for example, return flows) (Vaux and Howitt, 1984; Young, 1986).

Water markets can also be established informally, which typically involves water users located in a specific region or sharing a water resource. Informal water trading arrangements, for example, can include arrangements between neighbours and come in diverse forms (for example, private tube-wells in India or informal swapping of water in the United States, Spain and Mexico) (De Stefano and Hernández-Mora, 2016; Mukherji, 2008).

Another form of water markets includes water quality trading (which is similar to carbon emission trading). It involves regulation of the discharge of point sources (for example, industrial or urban) and allows trading of credits between polluters, with money generated often being used to encourage activities to reduce discharge of nutrients from non-point sources (for example, agriculture). The remainder of this book concentrates mainly on water quantity markets, but for further discussion on water quality markets see Uchida et al. (2018) and Leonard et al. (2019).

1.4 EVALUATING WATER MARKETS

As elaborated further in Chapter 2, there are many ways to evaluate the performance of water markets. Water allocation regimes, such as water markets, typically aim to comply with economic efficiency terms (focusing on wealth creation by a resource) and social equity considerations (focusing on the wealth distribution among sectors and individuals) (Dinar et al., 1997). The three distinct forms of economic efficiency associated with water markets are:

1. Allocative efficiency: improving water resource short-term decision-making to help reflect seasonal conditions (for example, weather, commodity price adjustments, cropping choices) is facilitated by water temporary trade.
2. Dynamic efficiency: improving water resource structural or long-term decision-making to reflect new investment opportunities, regulatory shifts in access arrangements (for example, extraction limits or embargos) or personal strategic choices (for example, retirement), which is best achieved through water permanent trade.
3. Productive efficiency: water price changes (both temporary and permanent) offer incentives for the efficient use of water resources as either an investment or input for productive outcomes.

Grafton et al. (2011) introduced an integrated framework to assess and compare the institutional foundations, economic efficiency and environmental sustainability of water markets around the world. The framework highlights important linkages between water market development, institutional constraints and management goals, and helps to identify which water markets contribute to integrated water resource management, which features of water markets require further development and how water governance can be improved (Grafton et al., 2011).

Grafton et al. (2016) provide extensive commentary about various arguments for and against water markets, including: privatisation (allocation of individual rights), deregulation (diminishment of the regulatory role of public organisations), decentralisation (transfer of decision-making and responsibility to a subsidiary level of authority), corporatisation (shift from public to corporate ownership), commercialisation (adoption of business models of practice and decision-making), marketisation (use of markets to determine use) and resource commodification (treatment of natural resources, including water, as a market good). Often those who argue against markets do so because they believe markets are a tool of global capitalism that results in appropriative privatisation, where state or private actors obtain water resources (without meaningful compensation) previously held in common ownership. However,

as Griffin et al. (2013) and Grafton et al. (2016) emphasise, there is a clear need to distinguish between infrastructure privatisation and water licence privatisation. Also, while there may be examples of privatisation leading to appropriation, the issue that must be focused upon is whether this is the market's fault, or whether it is a result of the institutions that surround markets and market failure. Understanding market failure and preconditions needed for water markets is critical for their success.

1.5 WHAT HAS THE WATER MARKET LITERATURE STUDIED TO DATE?

To understand the focus and overview of the water market literature around the world, we conducted a search of the literature from January 1970 to December 2019 in the electronic databases Web of Science, ScienceDirect, ProQuest Central, Earth, Atmospheric and Aquatic Science Database and Google Scholar. The phrases 'water market', 'water trading', 'water trade', 'ground-water markets', 'water rights', 'water entitlements' and 'water allocation' were used as search terms for title, keywords and anywhere in the text. A flow chart of the literature selection process is included in Figure 1.1.

Figure 1.1 Systematic review of water market literature, 1970–2019

Our search was restricted to published English language studies, peer-reviewed journal articles relevant to water market/trading. After further excluding science and engineering studies and those focusing on saltwater or bottled water, there were 465 highly relevant studies on freshwater markets (including both surface water and groundwater) from social science perspectives. These 465 selected publications are further analysed below.

Figure 1.2 shows the trend of publication numbers of all water market/trade-related studies and studies titled with ‘water market/trade’. The number of all water market/trade-related studies increases significantly from 1970 to 2019, but the share of studies titled with ‘water market/trade’ increases only slightly every year. Since the mid-1980s, the share of studies titled with ‘water market/trade’ has grown less than proportionally to the total number of water market-related studies, suggesting a diversification of academic investigations from water markets per se to a broader variety of related issues.

Figure 1.2 Cumulative number of studies in the water market/trade related literature, 1970–2019

Figure 1.3 shows the publication number trend. The annual average number of water market-related studies has increased from 0.4 in the 1970s to 23.2 in the 2010s. In the 2000s, the annual number of water market/trade-related studies increased significantly.

Most of these publications focus on water market issues in Australia (164 studies), which is the driest continent in the world. The United States (mostly the western states) receives the second-largest share of this literature (128 studies). China also has a significant share of the literature (33 studies), most of which were published in the 2010s. Studies on these three countries consist of more than 71 per cent of the selected publications.

Figure 1.4 presents the regional distribution of study contexts, where general water market investigations (without a specific country focus) are excluded. It is seen that most studies are on countries where certain regions face significant water resource constraints.

Figure 1.3 *Number of annual relevant studies in the water market/trade literature, 1970–2019*

Figure 1.4 *Regional distribution of water market study contexts, 1970–2019*

The type of water market (for example, rural, urban, other – no specific focus) was identified from 458 publications: 259 studies investigated rural water markets, focusing particularly on agricultural water use and management; 22

studies studied water demand/consumption issues in urban areas; while 71 studies jointly considered both rural and urban areas to investigate water distribution issues among different production/consumption sectors. The remainder had no specific rural or urban focus.

Regarding analytical approaches, in our review of the water market literature, 210 studies (43.9 per cent) used qualitative methods and 261 studies (54.6 per cent) employed quantitative tools including theoretical economic modelling, optimization, simulation and econometric methods. A mixed-methods approach was used by 0.4 per cent of studies; and 1.1 per cent were literature syntheses.

Water market studies are published across a variety of disciplines. According to the Web of Science journal classifications, popular journal categories included Water Resources (253 studies), Economics (122 studies), Environmental Sciences (45 studies), Agricultural Economics and Policy (76 studies), Law (27 studies) and Development Studies (24 studies), among others (double-counting applies, as most journals are classified into two or more categories). Popular outlets included: *Water Policy* (27 studies), *Water Resources Research* (25 studies), *Agricultural Water Management* (23 studies), *Australian Journal of Agricultural and Resource Economics* (18 studies), *Journal of Hydrology* (17 studies), *Ecological Economics* (14 studies), *International Journal of Water Resources Development* (12 studies), *Natural Resources Journal* (11 studies), *American Journal of Agricultural Economics* (11 studies), *Water International* (10 studies) and *Journal of Environmental Management* (9 studies), among others.

Popular research topics of selected publications are presented in Table 1.1. There has been a wide variety of different research questions investigated in the literature, from understanding important preconditions for water markets, to analysing water market price and volume drivers, to understanding net overall benefits from water markets.

1.6 THIS BOOK

Given the increasing interest in water markets and the growing water market literature, Wheeler et al. (2017; which is republished with minor changes in Chapter 2) sought to develop an assessment framework for evaluating the practical benefits and institutional bases for the implementation and sustainability of water markets to address scarcity issues, called the water market readiness assessment (WMRA) framework. The WMRA consisted of three institutional factors as a prerequisite for establishing water markets:

1. Step one: enabling institutions. Defining the total resource pool available for consumptive use and hydrological factors of use; and evaluating

Table 1.1 Popular research topics in the water market literature, 1970–2019

Research topic	Typical approach	Some examples (not exhaustive)
Feasibility of introducing water market(s) and framework assessment	Qualitative	Zarour and Isaac, 1993; Becker and Zeitouni, 1998; Bjornlund and McKay, 2000; Bate, 2002; Bjornlund, 2003; Vasquez, 2008; Grafton et al., 2011; Akram, 2013; Kirsch and Maxwell, 2015; Grafton et al., 2016; Prieto, 2016; Wheeler et al., 2017; Petterini, 2018
Water market performance	Qualitative and quantitative	McCarl et al., 1999; Neuman and Chapman, 1999; Mahan et al., 2002; Newlin et al., 2002; Zekri and Easter, 2005; Pujol et al., 2006; Bauer, 2010; Culp et al., 2014; Grafton and Horne, 2014; Wheeler, 2014; Wheeler et al., 2014; Bauer, 2015; Leonard et al., 2019
Privatisation and marketisation of the water sector	Qualitative	Glennon, 2004; Borzutzky and Madden, 2013; Glennon, 2015; Grafton et al., 2016
Water market policy evaluation	Qualitative and quantitative	Rosegrant et al., 1995; Brennan, 2006; van Heerden et al., 2008; Garrick and Aylward, 2012; Garrick et al., 2013; Jamshidi et al., 2016
Water demand and price analysis	Quantitative	Zarnikau, 1994; Saleth and Dinar, 2001; Ipe and Bhagwat, 2002; Yoskowitz, 2002; Garcia et al., 2005; Gulyani et al., 2005; Zilberman and Schoengold, 2005; Pullen and Colby, 2008; Wheeler et al., 2008a; Zuo et al., 2019; Schwabe et al., 2020
Farmers' willingness to pay for water or participate in water market	Quantitative	Saleth and Dinar, 2001; Ranjan and Shogren, 2006; Giannoccaro et al., 2015; Venkatachalam, 2015; Jaghdani and Brümmer, 2016; Wheeler et al., 2009, 2010
Human behaviour in water markets	Quantitative (experimental)	Lefebvre et al., 2012; Broadbent et al., 2014; Hansen et al., 2014; Nauges et al., 2016
Institutional arrangements and transaction costs	Qualitative and quantitative	Howitt, 1994; Shatanawi and Al-Jayousi, 1995; Nieuwoudt, 2000; Carey et al., 2002; Hadjigeorgalis and Lillywhite, 2004; Zhang et al., 2009; Zhao et al., 2013; Erfani et al., 2014; Breviglieri et al., 2018; Loch et al., 2018
Case studies: water market successes and failures	Qualitative and quantitative	Burness and Quirk, 1980; Yoskowitz, 1999; Bakker, 2002; Zegarra, 2002; Bauer, 2010; Zavalloni et al., 2014; Bauer, 2015
Water trade modelling	Quantitative	Louw and van Schalkwyk, 2001; Turrall et al., 2005; Zaman et al., 2009; Alevy et al., 2010; Loch et al., 2011; Wittwer, 2011; Hung et al., 2014; Regnacq et al., 2016; Wheeler et al., 2008a, 2008b; Zuo et al., 2019

Research topic	Typical approach	Some examples (not exhaustive)
Design of water rights	Qualitative and quantitative	Johnson, 1971; Shupe et al., 1989; Michelsen and Young, 1993; Rosegrant and Binswanger, 1994; Ríos and Quiroz, 1995; Matthews, 2004; Solanes and Jouravlev, 2006; Whitford and Clark, 2007; Donohew, 2009; McKenzie, 2009; Nordblom et al., 2011; Raffensperger, 2011; Lefebvre et al., 2012; Jamshidi et al., 2016; Young, 2019
Inter-state water governance	Qualitative	Utton, 1985; Rodgers, 1986; Wheeler, 2014
Water use efficiency	Quantitative	Srivastava et al., 2009; Manjunatha et al., 2011; Razzaq et al., 2019
Environmental impacts	Quantitative	Tisdell, 2001; Lee et al., 2007; Rambonilaza and Neang, 2019
Climate impacts on water markets	Qualitative and quantitative	Pullen and Colby, 2006; Adler, 2008; Wheeler et al., 2008a, 2008b, 2013; Kahil et al., 2015; Ghosh, 2019; Zuo et al., 2019
Indigenous water rights/markets	Qualitative and quantitative	Nikolakis et al., 2013; von der Porten and de Loë, 2014; Nikolakis and Grafton, 2015; Taylor et al., 2016; Poirier and Schartmueller, 2012
Water quality trade	Qualitative and quantitative	Uchida et al., 2018; Leonard et al., 2019
Informal water markets	Qualitative and quantitative	Brozovic et al., 2002; Garrick et al., 2019; Munala and Kainz, 2012; Sima et al., 2013; Venkatachalam, 2015; Jaghdani and Brümmer, 2016; Razzaq et al., 2019

the current institutional, legislative, planning and regulatory capacity to facilitate water trade, involving: (a) specifying each resource share in perpetuity while allowing for changes in the proportion allocated to each share (comprises setting caps and regulations on use); (b) fully assigning responsibility for managing supply risk to users; (c) ensuring enforcement, strict regulation of caps and monitoring/compliance; and (d) keeping transaction costs low.

2. Step two: facilitating gains from trade. Developing clear and consistent trading rules; assessing benefits and costs of market-based reallocation; for example, numbers of individuals who can trade (versus adoption of trade); homogeneity of water use, adaptation benefits, cost of water reform, ongoing trade transaction costs and assessment of externalities. There is a difference between legislating for water trade to occur, allowing transfers between a small number of individuals, versus broader water reform legislation (for example, creating water registers with transparent,

complete and fully accessible data, clearer trade rules, public information sources).

3. Step three: monitoring and enforcement. Use of water markets and water extractions need ongoing monitoring and enforcement to ensure compliance, as well as continued development of trade-enabling mechanisms, including: seeking to limit/reduce transaction costs, scanning for unanticipated externalities, developing new market products (for example, option contracts or forwards) and then implementing, if needed, new legislative changes and planning requirements. Water market rules need flexibility to ensure water security and manage future uncertainty (Wheeler et al., 2017).

The institutional framework factors outlined in steps one and three above are needed for any property rights regime, while step two lists specific institutional factors required for water markets in particular. Given that water markets are complex economic instruments to design, develop, implement and sustain over time, and the fact that many countries have started to consider water markets as a management tool, there is a need for further testing of the WMRA framework to validate its robustness and practical usefulness in the field, particularly in developing-nation contexts with relatively weak institutional arrangements.

The purpose of this book is thus to apply the WMRA framework in a wider range of contextual applications across as many different countries as possible. This extended WMRA application is aimed at providing detailed insights and lessons for other countries going forward. The country case study chapters sought to apply the WMRA framework in different contexts and wherever possible to identify (as examples): (1) the local policy and practical management attitudes toward water markets, and whether there is any understanding/willingness to explore water market capacity to deal with river basins under scarcity stress; (2) relevant stages of water reforms toward market-based economic instruments, and whether other approaches might be more feasible/appropriate; and (3) detailed examinations of particular aspects of the WMRA framework to identify current gaps or requirements for reform if markets are to be established and sustained over time.

1.6.1 Water Market Case Studies Explored in this Book

The chapters written by water policy expert scholars in this book span six continents, across 20 countries. Chapter 2 presents the original journal article of the WMRA framework, and this journal article undertook case studies of Tasmania, Spain and the Diamond Valley in the United States of America (USA). Following Chapter 2, the chapters are arranged by continent, namely: Africa, Asia, Europe, South America, North America and Oceania.

More specifically, in Chapter 3 Jamie Pittock and co-authors explore the presence and use of water markets in Mozambique, Tanzania and Zimbabwe. Alec Zuo and co-authors apply the WRMA framework to water markets in Zhangye City, China in Chapter 4; while Sophie Lountain and co-authors look at groundwater markets in West Bengal, India in Chapter 5. In Chapter 6, Kate Reardon-Smith and co-authors investigate water governance conditions in the Lower Mekong Basin, in particular for the countries of Myanmar, Lao, Cambodia, Thailand and Vietnam. In Chapter 7, Andrew Johnson and co-authors discuss Nepal's water management challenges; and in Chapter 8 Irfan Baig and co-authors discuss groundwater markets in the Indus Basin Irrigation System, Pakistan.

Chapter 9 by Simon and Arnaud de Bonviller discusses the extent to which water markets are implemented in France in the areas of Poitou Marsh Basin and the Neste system; and in Chapter 10 Carlos Pérez-Blanco provides an overview of the development of water markets in Italy, particularly focussing on the Po River Basin District. Chapter 11 by Rosalind Bark and Nancy Smith looks at water markets in England. Chapter 12 by Guillermo Donoso and co-authors summarises Chile's experiences with water markets.

Chapter 13 by Gina Gilson and Dustin Garrick looks at the growth of environmental water markets in the Columbia Basin (USA); while in Chapter 14 Julia Talbot-Jones and Quentin Grafton study water markets in Canterbury, New Zealand.

Chapter 15 summarises the key lessons learnt from all the case studies that have applied the WMRA framework, as well as providing a quantitative overview of the progress towards fully functioning water markets around the world.

Overall, we hope that this book will allow water professionals to more fully comprehend the practical issues associated with assessing water market implementation and, if desired and feasible, how to ensure their continued development for improved societal well-being and water allocation over time.

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